F.W.S. Fishery Leaflet
55
#555

UNITED STATES DEPARTMENT OF THE INTERIOR, Stewart L. Udall, Secretary
James K. Carr, Under Secretary
Frank P. Briggs, Assistant Secretary for Fish and Wildlife
FISH AND WILDLIFE SERVICE, Clarence F. Pautzke, Commissioner
BUREAU OF COMMERCIAL FISHERIES, Donald L. McKernan, Director

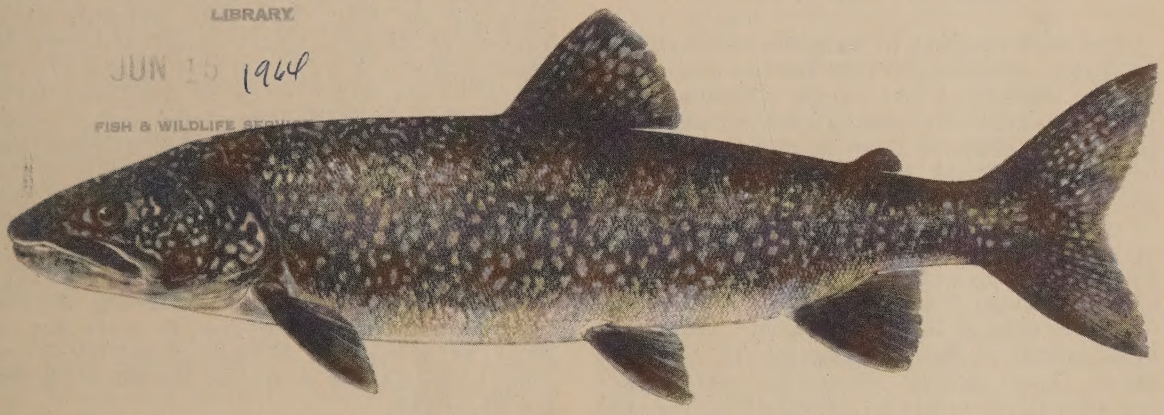
Fishery Leaflet 555

Washington, D.C. 20240 **February 1964**

THE LAKE TROUT (Salvelinus namaycush)

by Paul H. Eschmeyer

LIBRARY
JUN 15 1964
FISH & WILDLIFE SERV



The lake trout (also called mackinaw, togue, gray trout, Great Lakes trout, or namaycush) is a member of the salmon family (Salmonidae). Its body form, although variable, is usually moderately elongate and typical of the form shared by other trout and salmon. The scales are small, and the head, eyes, and mouth are large. The jaws, tongue, and roof of the mouth are strongly toothed. The conspicuous dorsal fin usually has 11 rays; a small fatty fin is located on the back near the tail. All fins are without spines; they are grayish, although the lower fins may show varying amounts of orange.

The body color of the lake trout varies widely; shades of gray and olive predominate. Much of the body is mottled with light gray or whitish spots, and vermiform tracings cover the head and back. The species is distinguished from the brook trout, which it resembles more closely than other trouts, by its deeply forked tail, by the absence of brightly colored spots on the body, and by the absence of conspicuous light edgings on the lower fins.

A number of different races or subpopulations of lake trout occur within its geographic range. The species has its greatest diversification in Lake Superior, where as many as a dozen subpopulations are believed to occur. Although fish of the different races often are not recognizable by external characters, their identity is perpetuated by distinctive differences in locality, depth, and/or date of spawning. One of the Lake Superior forms is the siscowet, or fat lake trout, which is commonly given subspecific ranking *(Salvelinus namaycush siscowet)*. As adults, most siscowets are extremely fat, deep-bodied fish that live at depths greater than 300 feet. The fat or oil content of the flesh of large specimens ranges up to nearly 70 percent--perhaps higher than in any other fish in the world.

Note.--Paul H. Eschmeyer, *Assistant Laboratory Director*, Bureau of Commercial Fisheries Great Lakes Research, Ann Arbor, Mich.

The color of the flesh of lake trout may range from white to deep reddish orange among fish taken from the same waters. The flesh has a fine, delicate flavor that is highly regarded by epicures. The siscowet, however, is much too oily for ordinary use and is usually smoked for the market.

The present account of different aspects of the life history of the lake trout is condensed from a large number of publications based on studies in many different waters. It is revised from Fishery Leaflet 441 issued in 1957. The illustration on page one is by courtesy of the New York Conservation Department.

GEOGRAPHIC DISTRIBUTION

The lake trout is principally an inhabitant of large, cool freshwater lakes of northern North America. Its range extends from Alaska eastward to the Labrador Peninsula, south to northern New England, and west through New York, the Great Lakes drainage basin, the northern margin of the Mississippi River watershed in Wisconsin and Minnesota, and the headwaters of the Columbia and Fraser Rivers and Vancouver Island, British Columbia. The species has been introduced widely in lakes of the west. Its principal center of abundance formerly was in the upper Great Lakes, where for many years the annual commercial production averaged nearly 15 million pounds. In recent years, however, predation by the sea lamprey *(Petromyzon marinus)* has brought the species near extinction in Lakes Huron and Michigan, and has greatly reduced the population in Lake Superior.

Lake trout spend most of their lives in the deeper waters of the cold lakes in which they occur. They move about extensively, however, and may be found at any depths at certain seasons or localities. In the Great Lakes they are usually most abundant at depths between 100 and 300 feet. Generally they live at or near the bottom, but some may occur also in the open water, far offshore, where they are caught commercially on set lines or in gill nets suspended below the surface. In smaller inland lakes in the southerly part of their range, the warming of the surface water restricts lake trout to deep water in summer. They seldom remain for extended periods in water with a temperature greater than 65° F.; they prefer temperatures of about 50° F. Siscowets of Lake Superior may spend their entire life in water at a much lower temperature, which probably seldom exceeds 40° F.

In the lakes where they occur, lake trout are more abundant in some localities than in others, yet they seldom form compact schools. Even the young are scattered and seem to have more or less solitary habits.

The principal associates of lake trout in the deep water where they live are sculpins, ciscoes, whitefish, and burbot.

REPRODUCTION

Spawning seasons and grounds.--Lake trout spawn once a year, usually in late summer or fall. The date depends on a variety of factors, which apparently include physiological differences among races, physical characteristics of the lake, latitude, weather conditions, and water temperatures. Most spawning is in October, but the breeding season begins in August in the northern part of the range and extends into November in the Great Lakes and into December in certain New York lakes. The time of spawning varies from year to year, and the duration of the breeding season varies in different waters. It lasts for as little as a week in certain inland lakes but may continue for a month or more in the Great Lakes.

Typical spawning grounds of lake trout are rocky (gravel, rubble, boulders), wave- or current-swept shoals, at water depths that range from a few inches in some inland lakes to as much as 100 feet in the Great Lakes. Even greater depths and a different bottom type were frequented by lake trout of southern Lake Michigan (before their near extinction), where spawning occurred on a clay bottom at depths as great as 200 feet and more. As a further variation in spawning habitat, some lake trout migrate up tributary streams, where they spawn over rocky bottoms.

In Lake Superior, different races of siscowets spawn at depths ranging from 50 to more than 300 feet, and on dates extending from early June to late November.

Spawning behavior.--No nest or redd is built by lake trout. The males, which outnumber the females on the spawning grounds, congregate on the breeding area

before the females. They cruise over the bottom and clean it of debris, algal growth, and slime by fanning and rubbing the rocks of the substratum. Activity on the spawning grounds occurs mostly between dusk and midnight and reaches its peak shortly after dark, although a few males may be present at all times of the day during the height of the breeding season. Lake trout are polygamous; there is no vigorous fighting or defense of territory. During courtship a marked, but transitory color change occurs among the males: the back becomes light and silvery and a dark, lustrous stripe appears along each side. Spawning may occur with only one or two males and one female taking part, or several males and several females may compose a compact spawning group. Typically, one or more males approach and nudge or nip at a female and then press against her side, with the vents in close proximity. The bodies of the fish quiver, their mouths are usually open, and the dorsal fin of the male is held erect. Each act lasts for only a few seconds and undoubtedly must be repeated a number of times before spawning is completed. The fish breed at random over the cleaned area and make no attempt to bury or otherwise care for the eggs, which sink into crevices among the rocks.

Individual male lake trout may remain on or near the spawning grounds for 3 weeks or more, but after the spawning season is over the adults disperse widely from the breeding area. Although lake trout may move to distant points between breeding seasons, most return to the same spawning grounds each year.

Size and age at maturity.--Size and age at sexual maturity vary widely among lake trout in different waters or from different subpopulations. In certain Canadian lakes some lake trout mature at lengths as small as 12 inches, whereas in Lake Superior many do not mature until they are more than double this length (although fish of some races mature at lengths as short as 14 inches). Lake trout in some lakes or under hatchery conditions may reproduce at an age as young as 5 years (rarely 4 years), but first maturity probably seldom occurs at ages less than 8 years among female lake trout of southern Lake Superior, and does not occur until 13 years in Great Bear Lake, Canada. In each water, the age and size at first maturity are not uniform--some individuals may mature one or more years earlier (or at a smaller size) than others. In general, males mature at an earlier age and smaller size than females. Varying numbers of mature lake trout in some lakes do not spawn each year, but may skip one or more spawning seasons, during which eggs or milt are not produced.

Production of eggs.--Maturing eggs in the ovaries of female lake trout undergo the major portion of their development during the 5 months preceding the spawning season. At the beginning of this period the paired ovaries are elongated, fleshy organs lying beneath the air bladder; their weight is less than 2 percent of the total weight of the fish. Just before spawning the heavily laden ovaries fill a large proportion of the body cavity and make up about 12 to 18 percent of the weight of the fish. Mature eggs in the ovaries are large (1/6- to 1/4-inch diameter) for a freshwater species, but their size varies considerably among fish of different subpopulations or from different localities. The size is not correlated with the size of the parent; small lake trout produce fewer, but not smaller, eggs than do large lake trout.

The number of eggs produced by lake trout often varies widely among individuals of the same size, but shows an average increase with increasing size of the fish. The number laid during a spawning season ranges from about 1,000 for small fish (15 inches long) from inland lakes to as many as 18,000 for large lake trout (32 inches long) from the Great Lakes. The number of eggs produced per pound of weight of the parent ranges from 400 to 1,200 and averages about 700; this value tends to be higher for large than for small fish.

After the mature eggs have been laid, two sizes of tiny eggs (one group about the size of a pin head and the other still smaller) remain distributed through the ovarian tissue.

Eggs on the spawning grounds.--Lake trout eggs are eaten by a variety of species of fish (including lake trout), as well as by mud puppies *(Necturus maculosus)*, and other animals which frequent the spawning grounds. Egg predation apparently is restricted largely to the spawning season, however, and to eggs which do not reach such protected situations as the crevices among rocks.

Eggs are so difficult to collect from their rocky environment that few egg-fertility studies have been made. It appears, however, that natural spawning is efficient. In one sample of more than 300 eggs collected from shallow-water spawning grounds in Otsego Lake, New York, 94 percent had been fertilized and 79 percent were still alive after having been on the lake bottom for a month.

Lake trout eggs develop slowly in the cold water in which they are laid and may require as much as 4 months or longer to complete their embryonic development. The eggs hatch into relatively helpless larvae, about 0.6 inch long, with a large yolk sac and a large mouth.

THE YOUNG

Newly hatched lake trout undergo their early development in the protection of the rocks of the spawning grounds. In about 1 month, after the absorption of part of their large yolk supply, they enter deeper water, beyond the spawning grounds (except in far northern waters, where they remain among the boulders near shore for several years). In Lake Superior, most small lake trout remain at depths of 100 feet or less throughout the first summer, but are found in deeper water after the equinoctial storms of fall.

The early growth of lake trout, during the period when the yolk is being absorbed, is slow; the rate increases markedly from late July to mid-September, and declines again to a slower rate in the fall. By the end of the first full year of life the average length ranges from less than 2-1/2 inches in the far north to nearly 4 inches in southern Lake Superior, and 3-1/2 to 5 inches in Lake Michigan.

The earliest food of lake trout, eaten before the yolk is completely absorbed, consists of microscopic animal life (zooplankton) and tiny insects. In waters where it occurs, a nutritious, 1/2- to 3/4-inch-long crustacean, the opossum shrimp, becomes the favorite food by mid-July of the first summer, and remains the principal item of diet for the next several years. By way of foreshowing their later fish-eating habits, lake trout begin to eat occasional tiny larval fish at the age of about 4 months and at a length of only 1-1/2 inches.

AGE AND GROWTH

The rate of growth varies widely among individual lake trout from the same race or the same lake, as well as among fish from different races or waters. In Lake Michigan, the average total length at the end of the fifth year of life has been estimated on the basis of scale examinations to be about 16 inches (14 to 18 inches in different collections), whereas in Great Bear Lake, Canada, 10 years are required to attain this size. Tagged native lake trout recovered in Lake Superior or Lake Michigan, 1 or more years after marking, had an average growth of about 3 inches per year for fish 12 to 26 inches long. Thus the application of a "rule of thumb" of about 3 inches of growth per year provides reasonable estimates of the age of the smaller lake trout from these waters. At greater size the average annual increment of length decreases steadily and may amount to as little as 1/2 inch or less for fish over 36 inches long.

Although rate of growth in length decreases greatly among fish of large size, the rate of increase in weight rises markedly. This is shown by table 1, which gives the average weight of fish of different total lengths, between 8 and 42 inches, for lake trout from Lake Superior.

Lake trout are long-lived and attain large size. Slow-growing fish in cold northern waters have attained ages estimated to be as high as 37 years. Two fish hatched from eggs obtained from Lake Superior stocks were held in hatcheries through life spans of 24 and 28 years. The largest lake trout on record was 49.5 inches long and weighed 102 pounds; it was caught in a gill net in Lake Athabaska, Saskatchewan, in 1961.

FOOD

Lake trout feed almost exclusively on other animals. Except for this generality, the composition of the diet varies widely among fish of different sizes and from different waters. Small lake trout feed first on minute crustaceans and soon add larger crustaceans (such as opossum shrimp when they are available), insects, and small fish (especially sculpins). By the time the fish reach a length of 15 to 18 inches the diet is principally fish. The fishes eaten by lake trout are of whatever kind happen to be available in the immediate environment.

Table 1.--Length-weight relation of lake trout from Lake Superior

Total length	Number of fish	Average weight	Total length	Number of fish	Average weight
Inches		*Pounds*	*Inches*		*Pounds*
8	134	0.1	26	43	5.6
10	162	0.3	28	80	7.3
12	135	0.5	30	81	8.8
14	141	0.7	32	42	10.7
16	120	1.1	34	23	13.3
18	141	1.7	36	12	16.4
20	191	2.4	38	8	18.3
22	144	3.2	40	16	23.1
24	49	4.3	42	14	28.4

In the upper Great Lakes, ciscoes of several species make up a major portion of the diet of adult lake trout; other coregonines, sculpins, smelt, and a variety of small forage species also contribute. In Lake Ontario, as in certain New York lakes, alewives are important as lake trout food. In still other waters where food habits have been studied, yellow perch, smelt, suckers and minnows are important items in the diet.

Small lake trout have been found only infrequently in the stomachs of larger fish, probably because of the greater relative abundance of other forage species rather than because of any scruples against cannibalism. Large lake trout have been observed to feed voraciously on newly stocked lake trout fingerlings which were concentrated near the planting locality. In certain inland lakes it is believed that predation by large lake trout may severely limit the density of their own population.

Although most adult lake trout eat fish, some stomachs from this species collected from a number of waters have contained large quantities of terrestrial insects. In still another departure from the customary fish diet, lake trout of some inland lakes feed largely on zooplankton, especially in summer, when warming of the water discourages the fish from reaching the upper levels occupied by their usual forage. In populations restricted to invertebrate food during much of the growing season, the growth rate often is slower than in populations which have suitable forage fish available throughout the year.

MOVEMENT

In Lake Superior, individuals from some races of native lake trout move throughout the lake. Tagged individuals have been recovered as far as 300 miles from the tagging locality, and one fish is known to have traveled 190 miles within 19 days. Likewise, in Lake Michigan, tagged lake trout have moved more than 200 miles from the place of release. In both lakes, the larger fish moved the greater distances. Smaller tagged fish, less than about 16 to 18 inches long, seldom were recaptured at distances greater than 50 miles from their home waters.

In contrast to the far-ranging habits of lake trout of some races, very few fish tagged in South Bay, Lake Huron, were recaptured in waters outside of the Bay. Similarly, in Great Bear Lake, Canada, subpopulations of lake trout only 8 miles apart showed no tendency to intermix.

ARTIFICIAL PROPAGATION

Lake trout are hatched and reared artificially by conservation agencies at various localities in their geographic range. Eggs are taken from fish caught in nets set at their spawning grounds, or from hatchery-reared brood stocks. Eggs and milt are stripped from ripe fish by manual pressure on the sides of their bellies, collected in a suitable container, and thoroughly mixed. After the fertilized eggs have been washed and are water-hardened, they are transferred to hatcheries, where they are incubated in shallow trays suspended in troughs

of flowing water. The length of the incubation period depends on the water temperature. Hatching occurs in about 2 months at 47° F., 4 months at 39° F., and requires more than 5 months at 35° F. The hatching percentage varies widely in different lots of eggs but averages about 65.

Newly hatched fry have large yolk sacs and are relatively helpless. They begin feeding and swimming actively within about a month. Their first food in the hatchery ordinarily is finely ground meat, such as beef liver or beef heart. Other meats or dry animal and vegetable meals may be added to their diet later.

Lake trout are stocked at various sizes between the time of hatching and the age of 2 years. Both the cost of rearing and the probability of later survival increase in proportion to the duration of the rearing period. Currently, most young are stocked in the spring of the second year, when lengths may average 4 to 5 inches. Experiments with fin-clipped lake trout stocked in Lake Superior have demonstrated marked increases in survival when fish are held through their first winter before planting. The most favorable results from lake trout stocking are obtained from new introductions into suitable waters, or from plantings made to maintain populations in lakes in which the species fails to reproduce successfully. The value of stocking lake trout is questionable in lakes where natural reproduction is sufficient to sustain the populations.

Until recent years, few lake trout were reared to maturity in hatcheries for brood stock, principally because of the long period (4-1/2 to 6-1/2 years or more) required before the first eggs are produced. After the invasion of the upper Great Lakes by the sea lamprey threatened the extinction of lake trout, it became clear that large numbers of hatchery-reared fish would be needed to aid in the rehabilitation of the species. Rearing techniques were improved, and brood stocks were developed, particularly in the State of Michigan, where current production of lake trout eggs from hatchery-reared brood stock exceeds 6 million per year.

In recent years, interest has been revived, particularly in Canada, in the production of hybrids from cross-breeding female lake trout with male brook trout. These hybrids have been produced experimentally on a number of occasions in fish-cultural history, but seldom on a large scale. The hybrid fish (called "splake," "wendigo," or "moulac") shows fast growth (hybrid vigor), reaches good size, and is reported to fight well when hooked.

LAKE TROUT FISHERIES

Lake trout are so widely dispersed in their environment that dense populations or high production in any given water are unusual. In inland waters the average annual catch by sport fishing seldom exceeds 1 pound per surface acre and the far-flung commercial fishery of the upper Great Lakes has produced an average of less than one-half pound per acre per year.

Lake trout are highly desirable game fish, despite the fact that their fight at the end of a line is less spectacular than that offered by some other members of the salmon family. They are more vulnerable than most species to hook-and-line fishing, and depletion of stocks in inland lakes has been shown to result from angling alone. Most sport fishing is by trolling at considerable depths (50 to 200 feet, depending on the character of the fishing grounds) with copper or silver spoons, spinners, or live bait.

In the upper Great Lakes "deep-sea trolling" for lake trout was so effective that it was a recognized and productive commercial fishing method (average annual production, 1944-50, in Lake Superior--86,000 pounds). Sport trolling from party boats (cabin cruisers or renovated fishing tugs) began more than 30 years ago and was gaining popularity rapidly prior to the extensive destruction of lake trout stocks by the sea lamprey. Many thousands of pounds were taken. The average size in various years and localities ranged up to 8 pounds, but many 10- to 15-pound fish and some 25-pounders were caught. A record fish caught on hook and line in Lake Superior in May 1952 was 51-1/2 inches long and weighed 63 pounds, 2 ounces. The Great Lakes sport fishery for lake trout was limited for some years almost exclusively to Lake Superior and has now practically disappeared from this lake as well, because of destruction of lake trout stocks by the sea lamprey.

In addition to deep-sea trolling, "bobbing" through the ice is a well-known method of the sport fishery. Either live bait is used or pieces of lake herring are placed on hooks in a manner to simulate live fish when they

are bobbed up and down near the bottom (often at depths of 75 to 100 feet or more). Bobbing through the ice is a popular winter sport and for many years was especially productive in certain sheltered areas in Lake Superior.

The upper Great Lakes area was the major center for commercial production of lake trout for many years. Fish tugs were operated out of most port cities and towns lining the shores. Gill nets accounted for more than 70 percent of the production and set-hooks were next in importance; impounding nets, commercial trolling, and other methods combined yielded only about 5 percent of the total commercial catch. In the 10-year period 1931-40, the average annual production in the upper Great Lakes was 14.7 million pounds (worth well over $7 million at present prices). Of this total, Lake Michigan produced 36 percent, Lake Huron 34 percent, and Lake Superior 30 percent. Forty-two percent of the total catch was landed in Michigan ports, 33 percent in Ontario, 19 in Wisconsin, 3 in Minnesota, 2 in Illinois, and 1 percent in Indiana.

In addition to the Great Lakes, lake trout are caught commercially in a number of large inland lakes of Canada.

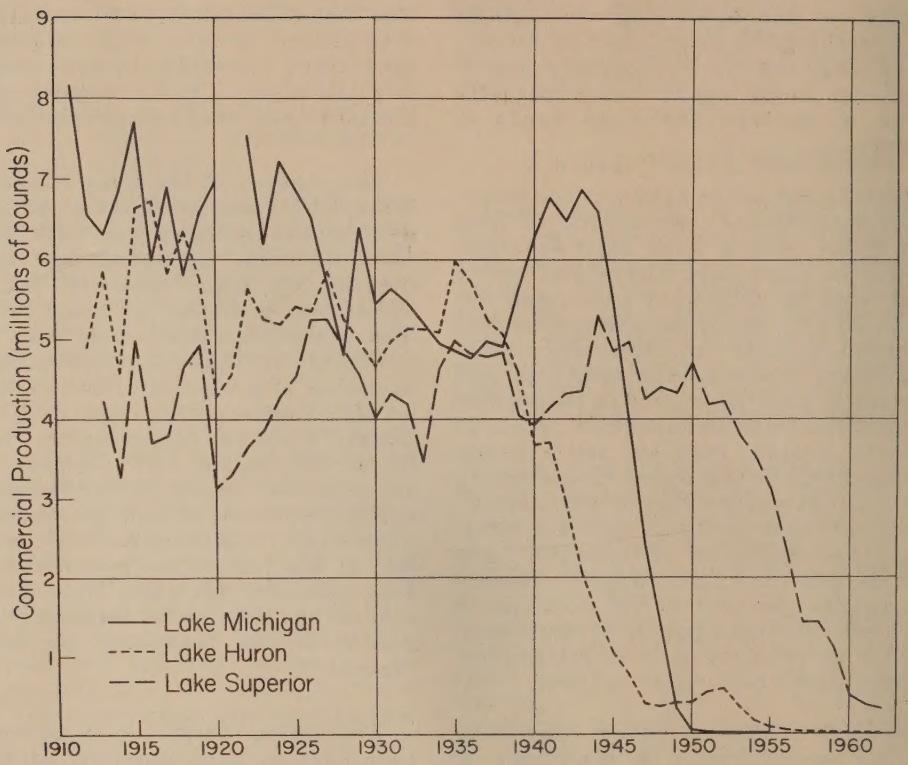
THE LAKE TROUT AND THE SEA LAMPREY IN THE GREAT LAKES

The commercial production of lake trout in the upper Great Lakes during the past 50 years is shown in the accompanying graph. In each lake, a long period of fluctuating but relatively high production was followed by the catastrophic collapse of the fishery in recent years, after the sea lamprey successively invaded Lakes Huron, Michigan, and Superior. In Lake Huron, a production which exceeded 5 million pounds as recently as 1938 dropped to less than 400,000 pounds in 1947 and 1,000 pounds in 1959; in Lake Michigan, the rate of decline in catch was even more precipitous, from more than 5 million pounds in 1945 to only 54,000 pounds in 1950 and 400 pounds in 1953; in Lake Superior, production dwindled from 4,700,000 pounds in 1950 to 368,000 pounds in 1961. The commercial fishery in Lake Superior was closed in mid-1962, and the catch of lake trout restricted to the minimum numbers necessary for scientific research on the lake trout-sea lamprey relationship.

The closure of the Lake Superior fishery followed the demonstration of the effectiveness of sea lamprey control in the spring of 1962, when the number of adult sea lampreys moving up Lake Superior tributaries to spawn was reduced by 86 percent from 1961. The control followed more than 15 years of research by Federal, Provincial, and State agencies of the United States and Canada, in an effort coordinated since 1955 by the Great Lakes Fishery Commission, an international body which was established by treaty between the United States and Canada. The definitive breakthrough was the discovery of a chemical (3-trifluormethyl-4-nitrophenol) that is toxic to sea lamprey larvae but harmless to other animals. This larvicide was applied to all Lake Superior tributaries known to be inhabited by sea lamprey larvae.

The sharp decrease in numbers of sea lampreys in Lake Superior allowed the lake trout population to begin recovery. The numbers of lake trout with lamprey wounds decreased markedly, and more of the fish grew to large size. Sexually mature fish of some races practically had been eliminated by the sea lamprey; consequently, little or no natural reproduction occurred in extensive sections of Lake Superior for at least 5 years. Large numbers of hatchery-reared fish, each marked by the removal of one or more fins, have been stocked in recent years to help fill in the missing year classes; about 1,800,000 yearling lake trout were planted in 1962 alone.

Experimental sea lamprey control thus far has been concentrated in Lake Superior, where a remnant of the native lake trout population still remains. The apparently successful control efforts underway there offer substantial hope that the species will again be restored to its former level of importance in the sport and commercial fishery throughout the upper Great Lakes.



Commercial production of lake trout in Lakes Michigan, Huron, and Superior.

MS #1318

Created in 1849, the U.S. Department of the Interior is concerned with the management, conservation, and development of the Nation's water, fish, wildlife, mineral, forest, and park and recreational resources. It also has major responsibilities for Indian and Territorial affairs.

As the Nation's principal conservation agency, the Department works to assure that nonrenewable resources are developed and used wisely, that park and recreational resources are conserved for the future, and that renewable resources make their full contribution to the progress, prosperity, and security of the United States--now and in the future.

GPO 867-383

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF COMMERCIAL FISHERIES
WASHINGTON, D.C. 20240

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF THE INTERIOR